Introduction to
Electrical Disturbances Apparently of
Extraterrestrial Origin

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"NEW RADIO WAVES TRACED TO CENTRE OF THE MILKY WAY" - So announced the New York Times on May 5, 1933.
"Mysterious static reported by K.G. Jansky, held to differ from cosmic ray. Direction is unchanging. Recorded and tested for more than a year to identify it as from Earth's galaxy. Its intensity is low. Only delicate receivable able to register - no evidence of interstellar signaling."

Today, we view this announcement of Jansky's paper entitled "Electrical Disturbances Apparently of Extraterrestrial Origin" presented at the meeting of the U.S. Committee of the International Union of Radio Science (URSI) in Washington, D.C. as the beginning of radio astronomy. But at that time it was neither the birth of a new science, receiving only passing notice from the astronomical community, nor greatly acclaimed by the scientific or engineering community. Who was this man, and how did this discovery come to be.

The Beginning:

Karl Jansky (see photo in Figure 1) was born in the territory of Oklahoma in 1905. His father was a professor of electrical engineering at the University of Wisconsin from 1908-1940 so Karl grew up in Madison in an academic environment. He attended the University of Wisconsin and obtained his BA in physics in 1927. He stayed on for another year doing graduate studies in physics and finished the course work for a Master's

but not the thesis. His Master's was finished years later using one of his Proceedings of IRE papers as a thesis.

Jansky joined the Bell Telephone Laboratories in New York City in the summer of 1928. He was assigned to continue the noise work already in progress on long waves. Overseas radiotelephone service had just begun and knowing more about noise, the static that infested the airwaves, was important. In particular, he was to study the direction of arrival of thunderstorm static. This data would be valuable since, if a predominant direction was found, the antennas used for transoceanic radio-telephone communication might be designed to give a minimum response in that direction, thereby improving the signal-to-noise ratio. One of the first steps in studying the noise in radio circuits is to build a suitable receiver. As reported by A. C. Beck in his personal recollections of Karl Jansky [1] most new members of the radio research staff were given as their first assignment the task of building a receiver incorporating all possible improvements and also adapting it to their own special needs. Jansky built a receiver that was much like the others then in use, but special attention was given to reducing noise originating in the receiver itself and to obtaining the best possible stability in long term gain. In order to measure static and noise, because of their high peaks of energy levels, he also gave special attention to the output circuits to avoid overload and then to integrate that output over some definite period so the received energy levels could be recorded. Incorporated in this set was a calibrating oscillator for use as a signal generator, and a precise vacuum tube voltmeter so that an accurately known signal could be recorded for calibration purposes, thus making possible accurate field strength measurements.

To study direction of arrival required an antenna that would rotate in a complete circle. Therefore Jansky built a vertically polarized unidirectional beam antenna of the Bruce curtain type as shown in Figure 2. The antenna was about 30 meters long by 3.66

meters high and mounted on four wheels running on a circular horizontal track to provide rotation in azimuth. A synchronous motor turned the structure one revolution every 20 minutes. As stated by Jansky in his paper "The array is highly directive in the horizontal plane and is rotated about a vertical axis so that data obtained with the system, ... give the horizontal component of the direction of arrival of the signals. ... the operation of the recorder is synchronized with that of the rotating array so that the records show directly the horizontal component of the direction of arrival as well as their intensity. The apparatus was tuned to a wavelength of 14.6 meters (20.5 MHz) during all the experiments."

Now Jansky had in place; 1) the largest rotatable directional antenna in existence at that time, 2) a quiet state-of-the-art receiver, 3) a receiver responsive to a relatively wide band of wavelengths and 4) an averaging arrangement to smooth out the pen trace on the recorder chart. In other words, Jansky, whether he knew it or not, had built the world's first radio telescope. In addition he was working for Bell Laboratories, which had always stressed the importance of careful and thorough experimental work, which called for very accurate and precise measurements. All of these elements would prove to be crucial to his discovery.

The Experiment:

Starting in late 1930 regular recordings of noise were made and Jansky began analyzing them. In a paper published in December 1932 [2], Jansky reported the first results with his equipment. He reported three groups of static (1) static from local thunderstorms, (2) static from distant thunderstorms found to come principally from southerly directions and (3) "... very steady hiss type static, the origin of which is not yet known." Jansky had a real live mystery in his hands. His paper details a very meticulous study to unravel this mystery and explain where the hiss type static came from. A very

thorough chronology of Jansky's work is given by Woody Sullivan in reference [3] from which most of the information that follows was derived.

The first real recognition of this unknown static was in January 1932 when he writes in his monthly work report "... A very steady continuous interference - the term 'static' doesn't quite fit it. It goes around the compass in 24 hours. During December this varying direction followed the sun."

Jansky eventually took data on this "hiss type static" for the entire year in 1932. Early in 1932 he observed that the daily peak was preceding the sun by as much as an hour. He was noticing a continual shift, "in accordance with the approaching summer session and lengthening day" and is quite curious as to what will happen after June 21st, the summer solstice. When he observed no effect on his data by a partial solar eclipse on Aug. 31, 1932 and that after summer solstice he observed that the curve was not going to shift back to the spring position, it was clear that the sun was not the source of the static. In December 1932, the astronomical aspect finally hits him. At that time, George Southworth asked Jansky to plot up data over the long term - put the whole year together in a more coherent fashion. That may have been an important suggestion for Jansky because by the end of December 1932 Jansky had determined that the direction of the source of the hiss-type static "always lies in a plane fixed in space."

The key illustration from his paper is his Figure 2, which discusses the astronomical interpretation. Plotted is the time of day versus the direction of arrival in azimuth, or, alternatively, a plot of sidereal time versus solar time over the year. The curves are labeled essentially by the different months of the year and you can see how it was shifting about two hours every month. Half of his paper, six out of twelve pages, was spent explaining what right ascension and declination are to the engineers. He

concluded that the main extra-terrestrial signal was coming from a right ascension of 18 hours and a declination of -10 degrees. This direction coincides with the constellation Sagittarius toward the center of the Milky Way. In the publication he made two very perceptive comments: He suggested that the radio emission was somehow connected to the Milky Way and that it originated not from stars but from ionized interstellar gas.

Today we know that the extremely high radio brightness temperature comes from synchrotron emission, i.e. radiation from electrons spiraling in a magnetic field, from the ambient interstellar medium.

Jansky was well aware of both the astronomical implications of his discovery as well as its practical considerations. For example, he noted in 1935 that "this star static, as I have always contended, puts a definite limit upon the signal strength that can be received from a given direction at a given time and when a receiver is good enough to receive that minimal signal it is a waste of money to spend any more on improving the receiver". Jansky recognized that further progress in understanding of this star noise would require larger antennas with sharper beams that could be pointed in different directions. He even proposed the construction of a 33 meter (100-foot) diameter parabolic reflector for use at meter wavelengths. For various reasons, he did not receive any support for this proposal and did not have much of an opportunity to continue his work studying star noise.

Perspectives:

Primarily, radio astronomy has been a technique-oriented science. Starting with Jansky, the major discoveries have been made by skilled scientists who, because they completely understood their equipment were able to spot and correctly interpret their unexpected results. Jansky's careful arguments about the origin of the radiation are